Obesity Research & Clinical Practice (2014) 8, e459—e465

ORIGINAL ARTICLE

Relationship between habitual sleep duration, obesity and depressive symptoms in patients with sleep apnoea

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Received 3 July 2013; received in revised form 7 November 2013; accepted 10 November 2013

KEYWORDS
Depression;
Gender;
Obesity;
Self-reported sleep duration;
Sleep apnoea

Summary
Objectives: Short sleep duration has been linked with obesity in general population, but this issue has not been addressed in patients with obstructive sleep apnoea syndrome (OSAS) separately. Depressive symptoms are frequent in OSAS and may affect sleep and energy balance. Our purpose was to assess the association of habitual sleep duration, psychological distress, depressive symptoms, and excessive daytime sleepiness with measures of obesity in patients with OSAS.
Methods: 210 middle aged consecutive patients (111 men and 99 women) referred for evaluation of suspected OSAS were divided into subgroups based on apnoea-hypopnoea index (AHI) and treatment suggested by a sleep physician.
Results: OSAS (AHI > 5/h plus symptoms) was diagnosed in 75.7% of the patients. Their sleep duration correlated negatively with psychological distress ($r = -0.22$, $p = 0.043$) and depressive symptoms ($r = -0.27$, $p = 0.013$) in men. No association was found between self-reported habitual sleep duration and measures of obesity or subjective sleepiness. In patients considered for CPAP therapy, sleep duration associated inversely with depressive symptoms both in men ($r = -0.28$, $p = 0.024$) and women ($r = -0.33$, $p = 0.037$). After adjusting for age and Epworth Sleepiness Score, the results remained essentially similar.
Conclusions: Our results suggest that self-reported habitual sleep duration does not associate with obesity in patients with OSAS. Shorter habitual sleep duration seems to associate with higher scores of depressive symptoms and psychological distress.

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1871-403X/$ — see front matter
http://dx.doi.org/10.1016/j.orcp.2013.11.004

Introduction

Short sleep duration is associated with obesity in numerous community-based [1,2] and in a few clinical patient cohorts [3]. Possible mechanism could be endocrine changes induced by sleep deprivation and resulting in altered regulation of energy balance. Epidemiological evidence [4] as well as results from interventional studies [5] support this hypothesis demonstrating low levels of the satiety hormone leptin in subjects with sleep deprivation. However, despite poor sleep quality and sleep deprivation, patients with obstructive sleep apnoea syndrome (OSAS) have increased leptin levels compared to controls [6]. This finding might also reflect differences in interaction between sleep and energy metabolism in OSAS patients compared with general population.

Although obesity is the most important risk factor for OSAS [7—9], only few studies addressing the relationship between obesity and sleep duration have included OSAS patients [3,10—12], leading to conflicting results. Of importance, none of those studies examined the association between sleep duration and obesity in a subgroup of sleep apnoea patients separately.

The prevalence of mood disorders is high among OSAS patients [13]. Weight change and appetite disturbance are well-known single compound symptoms of depression at all ages. We hypothesized that self-reported sleep duration would correlate positively with obesity, psychological distress, depressive symptoms and excessive daytime sleepiness in patients who were referred to the pulmonary clinic with suspected OSAS.

Materials and methods

Study population

The study population was recruited from 223 consecutive patients referred for a sleep study in the Department of Pulmonary Diseases at the Turku University Hospital due to suspected OSAS. The study protocol was approved by the ethics committee of the Turku University Hospital. Complete data set was available in 210 patients (111 men and 99 women) out of 223 patients who had provided their written informed consent.

Methods

In the evening prior to the sleep study, a trained nurse measured height, weight, neck, waist and hip circumference. Patients completed the questionnaires in the evening around 6 p.m. after a standard hospital meal. Average sleep time was queried (''During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)''). Insomnia was defined as difficulty in falling asleep, maintaining sleep, early morning awakenings or non-restorative sleep. Insomnia symptoms were evaluated by using sections from the Basic Nordic Sleep Questionnaire [14]. Data from use of hypnotics and coffee consumption was collected. Psychological distress was assessed with help of the 12-item General Health Questionnaire (GHQ-12) [15], depressive symptoms with the depression scale (DEPS) [16], and excessive daytime sleepiness with the Epworth Sleepiness Scale (ESS) [17]. Scores less than 3 for GHQ-12, less than 9 for DEPS and less than 10 for ESS were considered normal.

All patients underwent overnight in-hospital cardiorespiratory polygraphy (Embla®, Somnologica Software, Flaga hf. Medical Devices, Reykjavik, Iceland) including the measurement of inspiratory flow pressure profile via nasal prongs, abdominal and thoracic movements, electrocardiography, periodic leg movements, transcutaneous carbon dioxide partial pressure ($PTcCO_2$; TCM3, Radiometer A/S, Copenhagen, Denmark) and arterial oxyhaemoglobin saturation (SaO_2). SaO_2 was measured with a finger probe pulse oximeter (Oximeter Embla A10 XN, Embla, Denver, Colorado USA). The episodes of arterial oxyhaemoglobin desaturation of 4% units or more per hour (oxygen desaturation index, ODI4) were automatically determined from the SaO_2 signals with Somnologica software. Possible artefacts were manually removed by an experienced scorer. Episodes of apnoea and hypopnoea were visually determined by the same experienced scorer and expressed per hour (apnoea-hypopnoea index, AHI) in bed from lights off to lights on using internationally accepted criteria [18].

Statistical analyses

Data from the entire patient cohort was first submitted for statistical analyses to evaluate the characteristics of these patients with high probability of OSAS referred for a diagnostic sleep study. Patients were then divided into two groups based on AHI: (1) OSAS and (2) non-OSAS. OSAS was defined according to the criteria of the American Academy of Sleep Medicine [19]; i.e. patients had to fulfil criterion A or B (be symptomatic) and have AHI > 5/h. The OSAS group was further divided into two subgroups: (a) patients with clinically significant OSAS

Table 1 Demographic variables, questionnaire results and parameters of sleep-disordered breathing in OSAS and non-OSAS groups by gender. Data presented as mean ± SD except sleep length as mean (range). *p*-values refer to gender differences in each group. Asterixes or NS indicate level of significance between men and women in OSAS vs. non-OSAS groups.

	OSAS (AHI > 5/h)			Non-OSAS (AHI ≤ 5/h)		
	Men $n = 90$	Women $n = 69$	*p*-value	Men $n = 21$	Women $n = 30$	*p*-value
Age (years)	52.2 (12.1) NS	54.8 (10.9)**	0.15	52.0 (11.9) NS	47.1 (12.1)**	0.061
BMI (kg/m^2)	32.1 (6.4)*	34.3 (7.8)**	0.070	29.2 (4.0)*	30.0 (5.5)**	0.71
Neck (cm)	42.8 (3.7) NS	40.0 (4.0)*	<0.0001	41.3 (2.9) NS	36.9 (3.2)*	≤0.001
Waist (cm)	111.3 (14.4) NS	109.4 (17.3) *	0.57	102.5 (15.2) NS	97.2 (12.7)*	0.053
Waist-hip ratio	0.99 (0.06) NS	0.90 (0.05) NS	<0.0001	0.96 (0.08) NS	0.87 (0.07) NS	≤0.001
ESS	9.3 (4.9) NS	9.9 (4.8) NS	0.41	8.5 (5.4) NS	8.0 (4.2) NS	0.85
GHQ-12	2.8 (3.3) NS	3.2 (3.6) NS	0.51	2.9 (3.4) NS	3.7 (3.3) NS	0.19
DEPS	8.1 (5.8) NS	9.8 (6.0) NS	0.073	8.4 (5.7) NS	9.5 (6.1) NS	0.20
Sleep length (min)	410 (150—600) NS	404 (240—600) NS	0.89	377 (300—480) NS	405 (240—600) NS	0.38
AHI #/h	23.1 (19.2)***	25.1 (25.4)***	0.75	2.9 (1.5)***	3.0 (1.6)***	0.65
ODI4 #/h	16.6 (19.5)***	21.3 (29.6)***	0.97	3.0 (6.3)***	2.4 (2.1)***	0.61

NS = non-significant.
AHI, apnoea-hypopnoea index; BMI, body mass index; DEPS, depression scale; ESS, Epworth Sleepiness Scale; GHQ-12, 12-item General Health Questionnaire; ODI4, oxygen desaturation index; OSAS, obstructive sleep apnoea syndrome.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

considered for nasal CPAP therapy or (b) patients with mild OSAS whom oral appliance, nasal surgery, positional treatment, or merely weight loss was considered as an adequate therapy. Patients considered for CPAP therapy had AHI > 5/h plus moderate or severe sleepiness related to OSAS or AHI > 5/h plus mild to severe sleepiness plus a cardiovascular disease. The severity of sleepiness was defined according to the criteria of American Academy of Sleep Medicine, whether sleepiness produces mild, moderate or marked impairment of social or occupational function [19]. Moreover, we divided patients into the following four subgroups based on AHI: AHI ≤ 5/h, AHI 5.1—15/h, AHI > 15/h, and AHI > 30/h. Adjustments were made for age and ESS score. Data is presented as mean ± standard deviation or range. Gender differences were evaluated with Wilcoxon Two-Sample Test. Correlations were done with Spearman's rank correlation test or *T*-test depending on the distribution of the data. Differences in distribution of BMI and sleep length between those considered for CPAP therapy or not were assessed with Cochran—Mantel—Haenszel method. Statistical software package (SAS for Windows, version 9.1.3, Cary, NC, USA) was used for analyses. A *p*-value less than 0.05 was considered statistically significant.

Results

Demographics and OSAS

Demographic variables and questionnaire results by gender in OSAS and non-OSAS patients are presented in Table 1. OSAS was diagnosed in 159 (75.7%) of 210 patients with available AHI score, of whom 80 (50.3%) had mild OSAS (AHI 5.1—15/h), 39 (24.5%) moderate OSAS (AHI 15.1—30/h) and 40 (25.2%) severe OSAS (AHI > 30/h). AHI did not correlate with symptoms of insomnia (data not shown). Female OSAS patients were older (54.8 vs. 47.1 years, $p = 0.004$) and both male (BMI 32.1 vs. 29.2 kg/m^2, $p = 0.049$) and female (BMI 34.3 vs. 30.0 kg/m^2, $p = 0.004$) OSAS patients were more obese compared with non-OSAS patients. BMI did

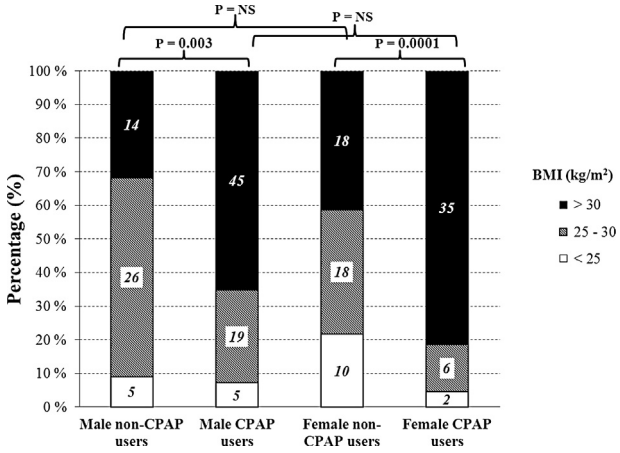

Figure 1 Percentage of normal (BMI < 25 kg/m^2), overweight (25—30 kg/m^2) and obese (>30 kg/m^2) patients among patients considered for CPAP treatment (CPAP users) or not (non-CPAP users). BMI = body mass index, NS = nonsignificant. *N* values are shown in the middle of the columns.

not correlate with DEPS, ESS, or GHQ-12 scores (data not shown).

Nasal CPAP was considered for 112 (53.3%), oral appliance or nasal surgery for six (2.9%), and merely weight loss with or without positional treatment for 41 (19.5%) of 210 patients. Patients considered for nasal CPAP treatment were more obese than those considered for weight loss or oral appliance (BMI 34.8 vs. 33.5 kg/m^2, $p < 0.0001$; Fig. 1), whereas sleep duration, ESS, GHQ-12, or DEPS scores did not differ.

Associations with sleep duration

Average self reported sleep duration was similar in males (6 h 50 min vs. 6 h 17 min, $p = 0.480$) and in females (6 h 44 min vs. 6 h 45 min, $p = 1.000$) with or without OSAS, respectively (Table 1). Distribution of short, mid-range and long sleepers did not differ among non-OSAS, OSAS with CPAP treatment or OSAS with other treatment group (data not shown). In the entire cohort, 10.3% used hypnotics at least twice a week and 29.6% of patients consumed coffee at least 5 cups per day. Sleep duration in hypnotics users or those with high coffee consumption did not differ from the rest of the cohort.

In OSAS group, shorter habitual sleep duration associated with higher frequency of symptoms of insomnia. In men, early morning awakenings ($r = -0.38$, $p = 0.002$) but in women, difficulty in falling asleep ($r = -0.34$, $p = 0.031$) or maintaining sleep ($r = -0.46$, $p = 0.003$) were associated with shorter sleep duration. Further, shorter habitual sleep duration associated with higher GHQ-12 and DEPS scores in men (Table 2), but in those considered for CPAP therapy, shorter sleep duration was linked with higher DEPS scores in both genders (Table 3). Habitual sleep duration did not correlate with measures of obesity, subjective sleepiness, or OSAS severity (Tables 2 and 3). No significant correlations were found in non-OSAS group (Table 2).

After adjusting for age and ESS score, the results remained essentially the same. In OSAS patients, sleep duration correlated negatively with DEPS score in the entire group ($r = -0.20$, $p = 0.014$) and in men ($r = -0.25$, $p = 0.026$), and tended to correlate negatively with GHQ score in men ($r = -0.19$, $p = 0.081$). No significant correlations were found in women with OSAS. Moreover, no significant correlations were found in the non-OSAS group.

In the subgroup with AHI 5.1—15/h, after adjustment with age and ESS, sleep duration tended to correlate with DEPS in men ($r = -0.31$, $p = 0.022$) and with waist-hip ratio in women ($r = 0.46$, $p = 0.071$). In the subgroup with AHI > 15/h, sleep duration in the entire subgroup correlated negatively with DEPS ($r = -0.24$, $p = 0.045$) and tended to correlate in the whole group ($r = -0.22$, $p = 0.060$) and in men with GHQ score ($r = -0.30$, $p = 0.052$) after adjusting for age and ESS. After adjustments in patients with AHI > 30/h, sleep duration correlated negatively with DEPS in the whole group ($r = -0.45$, $p = 0.006$) and showed tendency in men ($r = -0.43$, $p = 0.068$). After adjustments, sleep duration also correlated negatively with GHQ in the whole group with AHI < 30/h ($r = -0.38$, $p = 0.022$) and tended to correlate in women ($r = -0.45$, $p = 0.095$).

Discussion

In our cohort of obese symptomatic sleep apnoea patients, habitual sleep duration did not associate with measures of obesity or subjective sleepiness. Shorter sleep duration was linked with higher scores of insomnia symptoms, psychological distress or depressive symptoms. After adjusting for age and the ESS score, the results remained essentially the same.

Previous studies from cross-sectional cohorts have frequently linked short sleep with obesity although the results have been contradictory [1]. Some studies evaluating the association between sleep duration and obesity have included patients with OSAS [3,12,13] but have not examined the association separately in a subgroup of OSAS patients. In a mixed group of internal medicine patients, short sleepers had higher BMI [3]. A study

Table 2 Spearman correlations with self-reported habitual sleep duration (in min) in OSAS and non-OSAS groups by gender.

	Sleep duration					
	OSAS (AHI > 5/h)			Non-OSAS (AHI ≤ 5/h)		
	All $n = 159$	Men $n = 90$	Women $n = 69$	All $n = 51$	Men $n = 21$	Women $n = 30$
BMI (kg/m^2)	0.055 ($p = 0.50$)	0.12 ($p = 0.26$)	0.036 ($p = 0.78$)	0.17 ($p = 0.21$)	0.19 ($p = 0.32$)	0.14 ($p = 0.46$)
Neck circumference (cm)	0.13 ($p = 0.24$)	0.13 ($p = 0.35$)	0.14 ($p = 0.43$)	−0.33 ($p = 0.090$)	−0.12 ($p = 0.67$)	−0.091 ($p = 0.77$)
Waist circumference (cm)	0.16 ($p = 0.14$)	0.20 ($p = 0.15$)	0.11 ($p = 0.53$)	−0.13 ($p = 0.51$)	−0.051 ($p = 0.86$)	0.039 ($p = 0.90$)
Waist—hip-ratio	0.10 ($p = 0.36$)	0.03 ($p = 0.83$)	0.11 ($p = 0.56$)	−0.28 ($p = 0.15$)	−0.19 ($p = 0.51$)	−0.16 ($p = 0.60$)
ESS	0.0032 ($p = 0.97$)	−0.10 ($p = 0.36$)	0.16 ($p = 0.20$)	−0.11 ($p = 0.43$)	−0.11 ($p = 0.58$)	−0.12 ($p = 0.54$)
GHQ-12	−0.11 ($p = 0.19$)	**−0.22** ($p =$ **0.043**)	0.049 ($p = 0.71$)	−0.22 ($p = 0.098$)	−0.18 ($p = 0.36$)	−0.33 ($p = 0.076$)
DEPS	**−0.20** ($p =$ **0.017**)	**−0.27** ($p =$ **0.013**)	−0.076 ($p = 0.55$)	−0.065 ($p = 0.63$)	−0.080 ($p = 0.68$)	−0.052 ($p = 0.79$)
AHI #/h	0.027 ($p = 0.75$)	0.067 ($p = 0.54$)	−0.030 ($p = 0.82$)	−0.17 ($p = 0.26$)	0.042 ($p = 0.87$)	−0.25 ($p = 0.21$)
ODI4 #/h	0.10 ($p = 0.21$)	0.44 ($p = 0.69$)	0.18 ($p = 0.16$)	−0.16 ($p = 0.23$)	0.12 ($p = 0.56$)	−0.35 ($p = 0.063$)

AHI, apnoea-hypopnoea index; BMI, body mass index; DEPS, depression scale; ESS, Epworth Sleepiness Scale; GHQ-12, 12-item General Health Questionnaire; ODI4, oxygen desaturation index; OSAS, obstructive sleep apnoea syndrome. Significant correlations are bolded.

of female snorers found that with increasing severity of sleep apnoea and with increasing BMI there was a significant reduction in total sleep time [12]. Further, ESS score is more likely to identify sleepiness in men than in women [20]. In our study sleep duration did not associate with BMI or AHI in patients with OSAS. In women with mild OSAS (AHI 5.1—15/h), longer sleep duration tended to correlate with higher waist—hip ratio after adjusting for age and subjective daytime sleepiness although showed no tendency with BMI. This might suggest that central obesity may associate with longer sleep in women.

Self-reported sleep duration in our sleep apnoea patients was shorter than in general Finnish population (6 h 50 min vs. 7 h 23 min in men and 6 h 44 min vs. 7 h 37 min in women) [21]. Sleep duration in this study was self-reported as in most epidemiological studies, which could have attenuated the association between sleep duration and obesity. The lack of objective sleep measurements with actigraphy or polysomnography is a significant limitation of our study. It is well acknowledged that there is a considerable discrepancy between subjective reports and objective measurements of sleep duration. In the CARDIA cohort, persons sleeping 5 h according to actigraphy measurement, overestimated their sleep duration by 1.2 h, and those sleeping 7 h overestimated by 0.4 h [22]. However, those having the greatest risk for OSAS were the least likely to overestimate sleep and most likely to report it quite accurately in line with the actigraphy measured sleep [22].

Some studies suggest that short self-reported sleep duration may be associated with poorer health rather than actual sleep duration [22—24]. Prevalence of cardiovascular and metabolic comorbidity [9], insomnia [25] and depression [26] is high in patients with OSAS, which may explain the relatively short sleep duration found in our OSAS cohort. Generally, women are in greater risk for developing insomnia compared with men and the risk increases with age [27]. As expected, symptoms of insomnia were related with shorter sleep in our patients but surprisingly there was no gender difference. Insomnia may cause misperception of sleep duration [25,28], and both hypnotics use or coffee consumption might affect sleep duration. However, sleep duration in hypnotics users or heavy coffee drinkers did not differ from the rest of our cohort. Further, higher scores of psychological distress and depressive symptoms seemed to contribute to shorter sleep duration. Indeed, this is in line with the results from a random sample of middle-aged men and women, where the effect of chronic emotional

Table 3 Spearman correlations with self-reported habitual sleep duration (in min) in patients considered for CPAP therapy by gender.

	All $n = 112$	Men $n = 69$	Women $n = 43$
BMI (kg/m^2)	0.098 ($p = 0.31$)	0.15 ($p = 0.22$)	0.075 ($p = 0.64$)
Neck circumference (cm)	0.047 ($p = 0.72$)	0.13 ($p = 0.40$)	0.046 ($p = 0.85$)
Waist circumference (cm)	0.14 ($p = 0.29$)	0.17 ($p = 0.27$)	0.11 ($p = 0.64$)
Waist–hip-ratio	0.041 ($p = 0.75$)	0.045 ($p = 0.78$)	0.00 ($p = 1.0$)
ESS	−0.039 ($p = 0.69$)	−0.17 ($p = 0.16$)	0.19 ($p = 0.23$)
GHQ-12	**−0.21** ($p = 0.033$)	−0.23 ($p = 0.062$)	−0.17 ($p = 0.29$)
DEPS	**−0.30** ($p = 0.0013$)	**−0.28** ($p = 0.024$)	**−0.33** ($p = 0.037$)
AHI #/h	0.022 ($p = 0.83$)	−0.032 ($p = 0.81$)	0.064 ($p = 0.70$)
ODI4 #/h	0.11 ($p = 0.24$)	0.076 ($p = 0.54$)	0.17 ($p = 0.29$)

AHI, apnoea-hypopnoea index; BMI, body mass index; CPAP, continuous positive airway pressure; DEPS, depression scale; ESS, Epworth Sleepiness Scale; GHQ-12, 12-item General Health Questionnaire; ODI4, oxygen desaturation index. Significant correlations are bolded.

stress was a stronger determinant than that of BMI on the reported sleep duration [23].

Our results did not support our hypothesis that short sleep and obesity are linked in OSAS patients. However, due to rather small numbers in OSAS and non-OSAS groups, we cannot exclude the type 2 error. Lack of objective measurement of the sleep duration may affect our results. Neither sleep duration nor obesity associated with subjective daytime sleepiness or OSAS severity. Depressive symptoms seemed not to explain obesity in OSAS patients in our cohort. However, short sleep was associated with higher scores of depressive symptoms. Our results suggest that in patients with OSAS, shorter habitual sleep duration associates with insomnia symptoms, psychological distress and depressive symptoms.

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